RECOVERY OF AIRCRAFT SURVIVABILITY SUFFERED IN FLIGHT DUE TO RECONFIGURATION OF CONTROL ACTIONS

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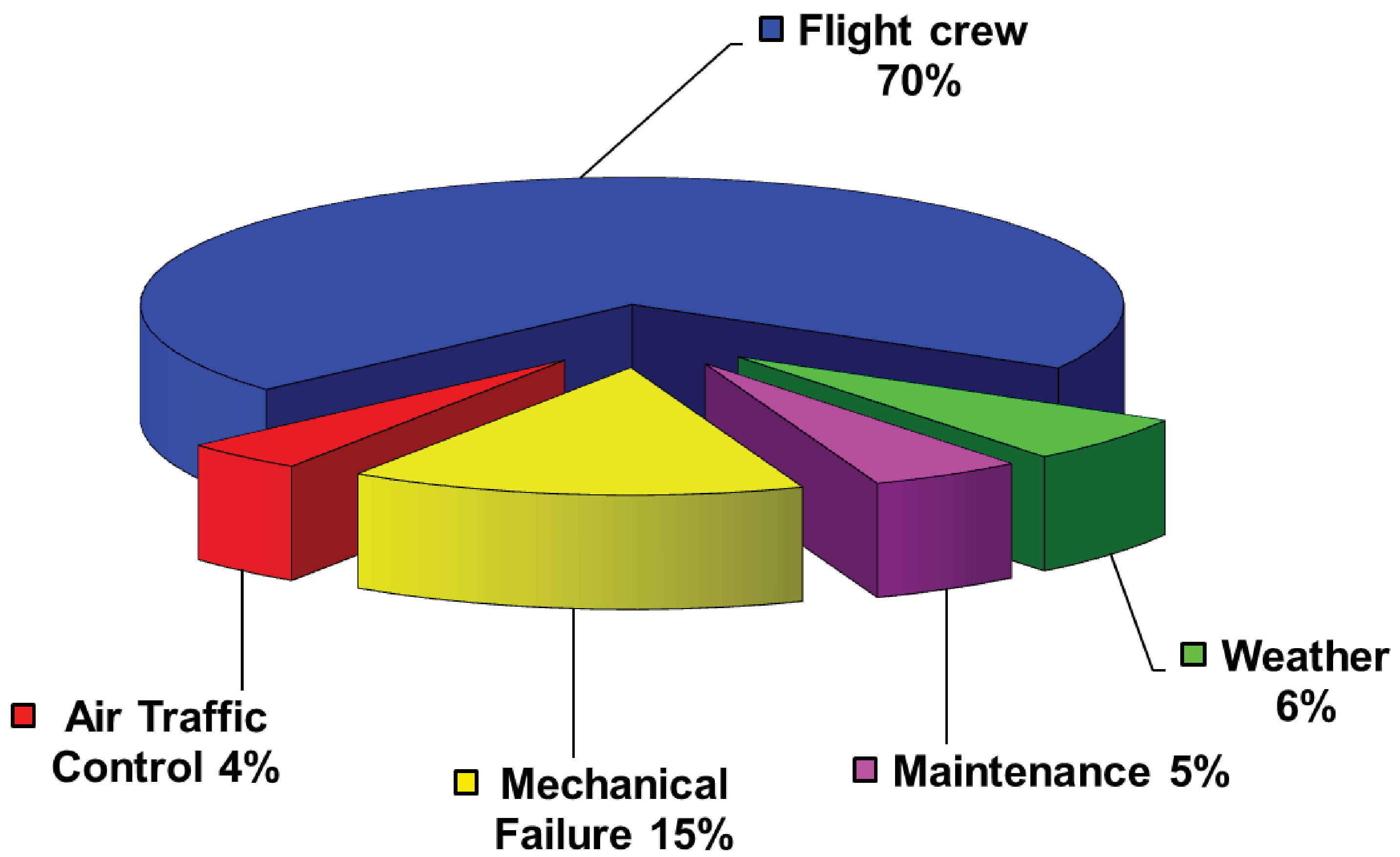
The aim is to ensure that aviation safety remains at current high standards or even improves regardless of air transport growth, through the increased enhancement of the safety of the aircraft itself and its systems.

Expected impact by 2020:

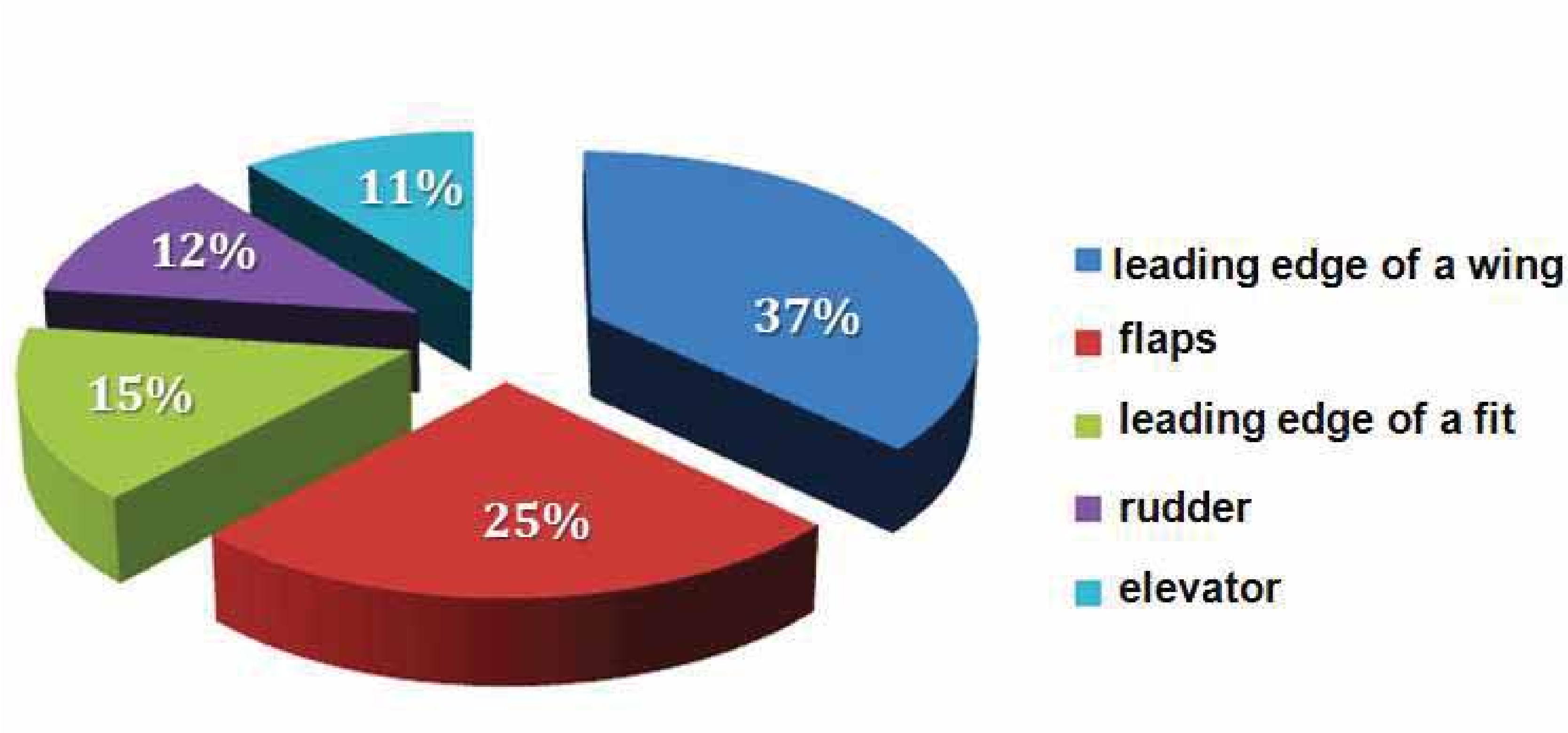
- To reduce accident rate by 80%.
- To achieve a substantial improvement in the elimination of and recovery from human error.
- To mitigate the consequences of survivable accidents.

AAT.2010.3.3-2. Systems and equipment

Causes of aircraft accidents



Statistic data of damages external outsides of the aircrafts




BRITISH AIRWAYS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Typical damages of outside of the aircraft

$$X = C_x S_h \frac{\rho V^2}{2}; \quad Y = C_y S_l \frac{\rho V^2}{2}; \quad Z = C_z S_s \frac{\rho V^2}{2}, \tag{1}$$

$$C_x = k(C_{xo} + \Delta C_{x\ \mathrm{st}} + \Delta C_{x\ \mathrm{el}}) + (1-k)C_x(M) + \Delta C_{x\ \mathrm{sp}} + \Delta C_{x\ \mathrm{ail}} + \Delta C_{x\ \mathrm{brak.guar}} + \Delta C_x^{\beta} + \Delta C_{x\ \mathrm{rud}} + \Delta C_{x\ \mathrm{dev}} + \boxed{\Delta C_{x\ \mathrm{dam}}};$$

$$C_y = C_{yo} + (\Delta C_y)_{\alpha=0} + \Delta(C_y^{\alpha})\alpha + C_y^{\bar{\dot\alpha}}\left(\frac{\dot\alpha ba}{V}\right) + C_y^{\bar\omega_z}\left(\frac{\bar\omega_z b_a}{V}\right) + \Delta(C_y^{n_y})n_y + \Delta C_{y\ \mathrm{st}} + \Delta C_{y\ \mathrm{rud}} + \Delta C_{y\ \mathrm{sp}} + \Delta C_{y\ \mathrm{brak.guar}} + \Delta C_{y\ \mathrm{dev}} + \boxed{\Delta C_{y\ \mathrm{dam}}}; \tag{2}$$

$$C_z = C_z(\beta) + \Delta C_{z\ \mathrm{el}} + \Delta C_{z\ \mathrm{dev}} + \boxed{\Delta C_{z\ \mathrm{dam}}};$$

Typical damages of outside of the aircraft

$$M_x = m_x S_h \ell_i \frac{\rho V^2}{2};$$
$$M_y = m_y S_l \ell_i \frac{\rho V^2}{2}; \qquad (3)$$
$$M_z = m_z S_s \ell_i \frac{\rho V^2}{2},$$

$$m_x = m_x(\beta) + m_x^{\overline{\omega}x}\left(\frac{\omega_x l}{2V}\right) + m_x^{\overline{\omega}y}\left(\frac{\omega_y l}{2V}\right) + \Delta m_{x\ \mathrm{ail}} + \Delta m_{x\ \mathrm{sp}} + \Delta m_{x\ \mathrm{rud}} + \Delta m_{x\ \mathrm{dev}} + \boxed{\Delta m_{x\ \mathrm{dam}}};$$

$$m_y = m_y(\beta) + m_y^{\overline{\omega}y}\left(\frac{\omega_y l}{2V}\right) + m_y^{\overline{\omega}x}\left(\frac{\omega_x l}{2V}\right) + \Delta m_{y\ \mathrm{ail}} + \Delta m_{y\ \mathrm{sp}} + C_z(\overline{X}_T - 0{,}25)\frac{b_a}{l} + \Delta m_{y\ \mathrm{rad}} + \Delta m_{y\ \mathrm{dev}} + \boxed{\Delta m_{y\ \mathrm{dam}}}; \qquad (4)$$

$$m_z = m_{zo} + (\Delta m_z)_{\alpha=0} + \Delta(m_z^{\alpha})\alpha + C_y(\overline{X}_T - 0{,}25) + m_z^{\dot{\alpha}}\left(\frac{\dot{\alpha} b_a}{V}\right) + m_z^{\overline{\omega}z}\left(\frac{\omega_z b_a}{V}\right) + \Delta(m_z^{n_y})n_y + \Delta m_{z\ \mathrm{st}} + \Delta m_{z\ \mathrm{elev}} + \Delta m_{z\ \mathrm{sp}} + \Delta m_{z\ \mathrm{brak.guar.}} + \Delta m_z^{\beta} + \Delta m_{z\ \mathrm{H}} + \Delta m_{z\ \mathrm{dev}} + \boxed{\Delta m_{z\ \mathrm{dam}}};$$

Mathematical model identification of typical damages outside of the aircraft

$$Z=\left[\alpha,\beta,n_x,n_y,n_z,\omega_x,\omega_y,\omega_z,\dot{\omega}_x,\dot{\omega}_y,\dot{\omega}_z\right]^T \qquad (1)$$

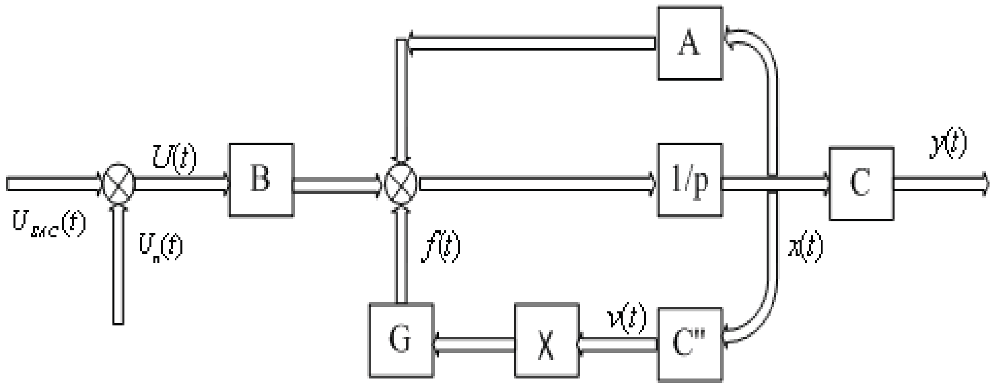
$$Z=\left[n_x,n_y,n_z,\dot{\omega}_x,\dot{\omega}_y,\dot{\omega}_z\right]^T \qquad (2)$$

$$\begin{bmatrix} n_x \\ n_y \\ n_z \end{bmatrix}=\begin{bmatrix} n_{xa} \\ n_{ya} \\ n_{za} \end{bmatrix}\begin{bmatrix} 1 & \alpha & -\beta \\ -\alpha & 1 & -\alpha\beta \\ \beta & 0 & 1 \end{bmatrix}\approx\begin{bmatrix} n_{xa} \\ n_{ya} \\ n_{za} \end{bmatrix}\begin{bmatrix} 1 & \alpha & -\beta \\ -\alpha & 1 & 0 \\ \beta & 0 & 1 \end{bmatrix}; \qquad (3)$$

$$\begin{bmatrix} \dot{\omega}_x \\ \dot{\omega}_y \\ \dot{\omega}_z \end{bmatrix}=\begin{bmatrix} K_x\omega_y\omega_z+K_{ax}m_x \\ K_y\omega_x\omega_z+K_{ay}m_y \\ K_z\omega_x\omega_y+K_{az}m_z \end{bmatrix}, \qquad (4)$$

$$Z=\left[(n_x+\Delta n_x),(n_y+\Delta n_y),(n_z+\Delta n_z),(\omega_x+\Delta\omega_x),(\omega_y+\Delta\omega_y),(\omega_z+\Delta\omega_z),(\dot{\omega}_x+\Delta\dot{\omega}_x),(\dot{\omega}_y+\Delta\dot{\omega}_y),(\dot{\omega}_z+\Delta\dot{\omega}_z)\right]^T \qquad (5)$$

Structure of multivariate system “flight crew – aircraft – environment – exceptional situations”



$$\dot{x}(t) = Ax(t) + Bu(t) + Gf(t) + D\varphi(x)$$

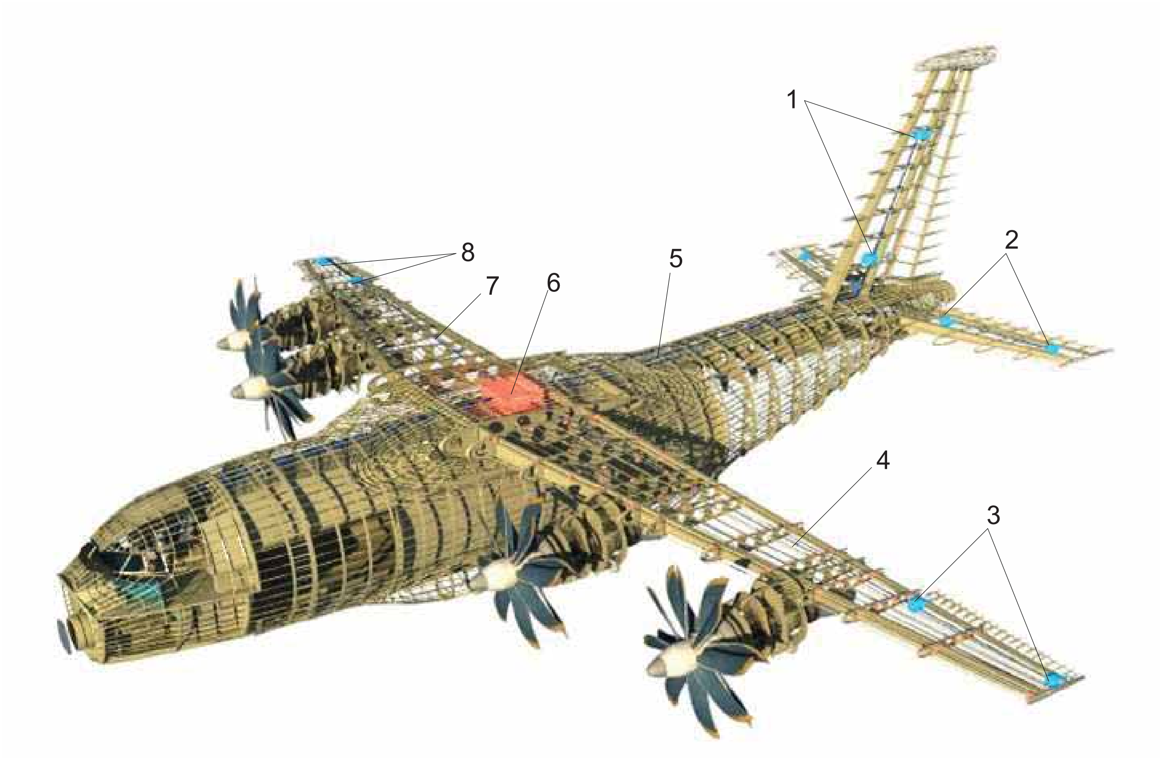
$$y(t) = Cx(t)$$

$$\nu(t) = C''x(t)$$

$$f(t) = \chi\nu(t)$$

$\overline{S}_{11}$	$\overline{S}_{12}$	0	0	0	0	0	0	0
$\overline{S}_{21}$	$\overline{S}_{22}$	$\overline{S}_{23}$	0	0	0	0	0	0
$\overline{S}_{31}$	$\overline{S}_{32}$	$\overline{S}_{33}$	$\overline{S}_{34}$	$\overline{S}_{45}$	0	0	0	0
$\overline{S}_{41}$	$\overline{S}_{42}$	$\overline{S}_{43}$	$\overline{S}_{44}$	$\overline{S}_{45}$	$\overline{S}_{46}$	0	0	0
$\overline{S}_{51}$	$\overline{S}_{52}$	$\overline{S}_{53}$	$\overline{S}_{54}$	$\overline{S}_{55}$	$\overline{S}_{56}$	$\overline{S}_{57}$	$\overline{S}_{58}$	0
$\overline{S}_{61}$	$\overline{S}_{62}$	$\overline{S}_{63}$	$\overline{S}_{64}$	$\overline{S}_{65}$	$\overline{S}_{66}$	$\overline{S}_{67}$	$\overline{S}_{68}$	$\overline{S}_{69}$
0	0	$\overline{S}_{73}$	$\overline{S}_{74}$	$\overline{S}_{75}$	$\overline{S}_{76}$	$\overline{S}_{77}$	$\overline{S}_{78}$	$\overline{S}_{79}$
0	0	0	0	$\overline{S}_{85}$	$\overline{S}_{86}$	$\overline{S}_{87}$	$\overline{S}_{88}$	$\overline{S}_{89}$
0	0	0	0	0	0	$\overline{S}_{97}$	$\overline{S}_{98}$	$\overline{S}_{99}$

System of diagnostics of external outside of the aircraft in flight based on fiber-optic intellectual structures

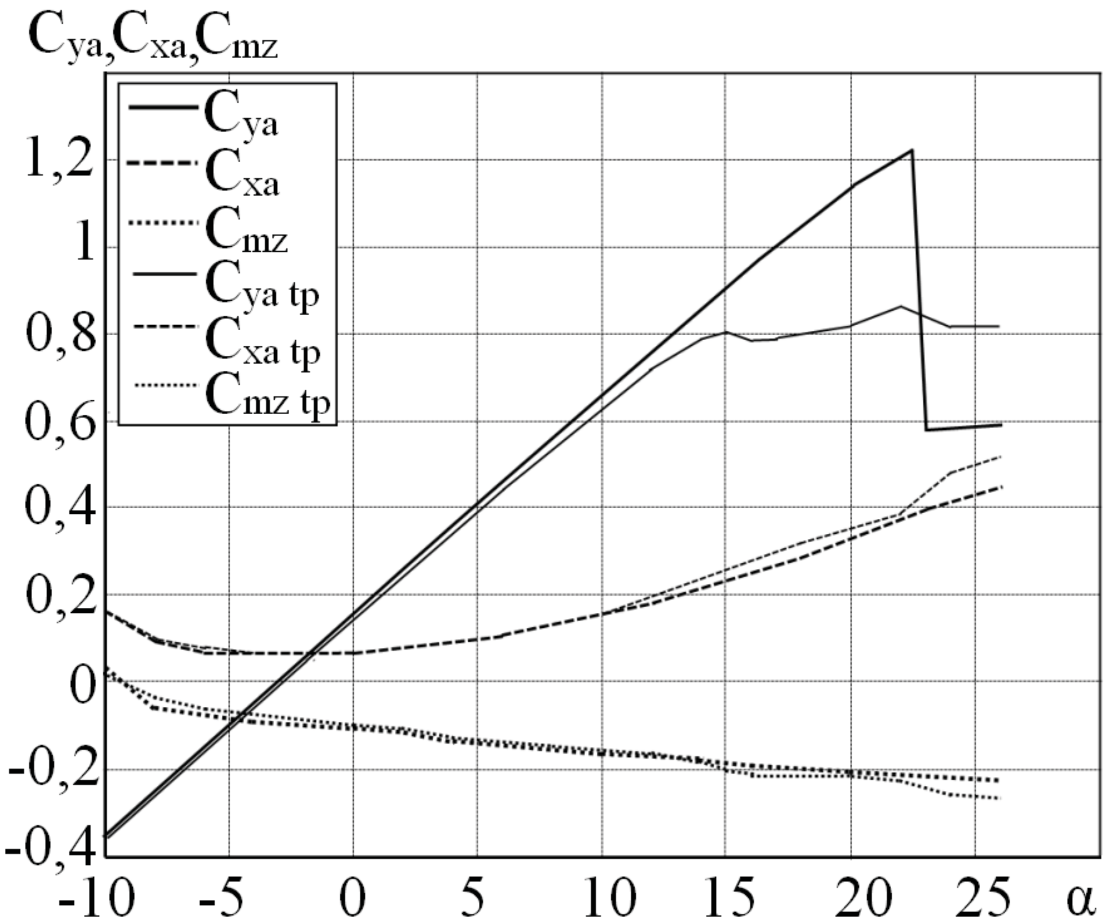


- 6 is pulse neuron network, for the classification of the standard damages of external aircraft outlines;
- 1, 2, 3, 8 are fiber-optic sensors (FOS);
- 4, 5, 7 are the optical plait, that connects several FOS

Equipments

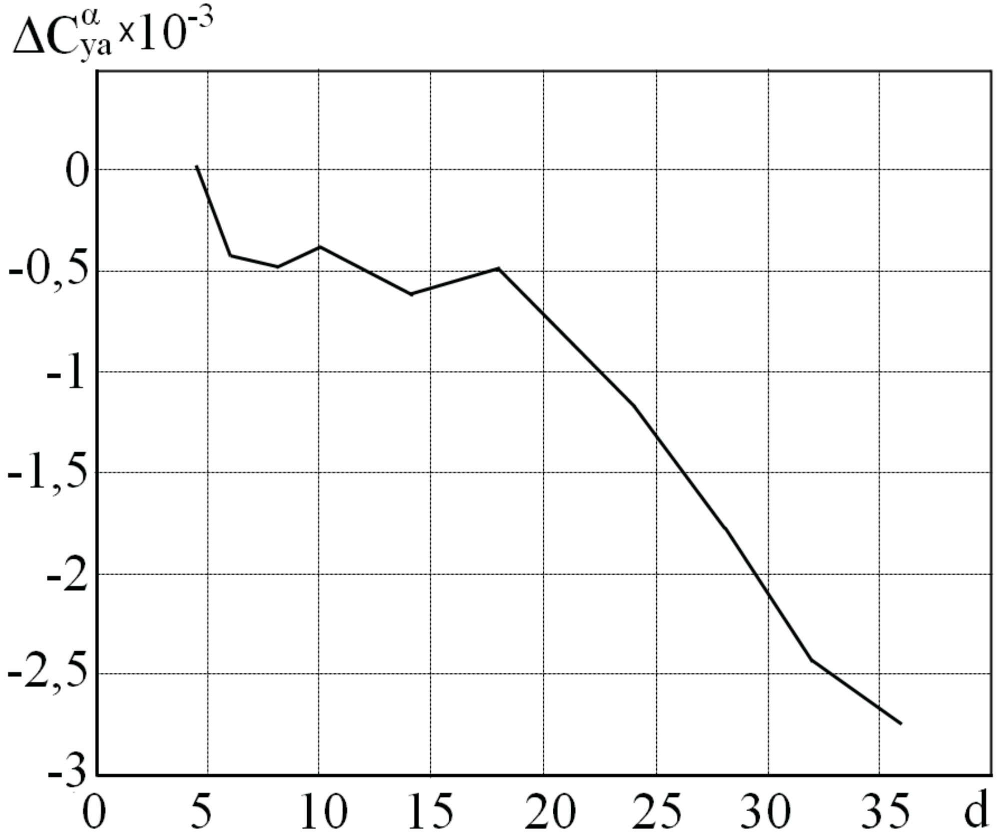
Equipments

Comparing of dependences of aero dynamical coefficients for undamaged wing and wing with typical damage imitation of 36 mm of size



Dependence of variation of maximal lift coefficient on typical damage size

Dependence of changing derivative of lift coefficient on typical damage size



Scientific classes that we are making research in:

-working on diagnostic technique for aircraft external outline as well as method of control reorganization in case of sudden damage of plane;

-developing system method of conservation of controllability for aircraft in exceptional circumstances and contingency during the flight;

-method preparation of rule base forming and developing decision-making technique and support for crew in existing flight situation with its help;

-development of operation algorithm and structure for on-board intelligence system that would prevent existing contingency during the flight from becoming catastrophic

We can help to:

- classify typical damages of an aircraft;

- place optimization for sensors to register time, degree and place of originated typical damages during the flight;

- develop control reconfiguration algorithm for compensation of negative influence of typical damages;

- make scaled-down experiment to prove method efficiency for aircraft external outline during the flight.

We are cooperating with various industrial enterprises: JSC Ukrtransgas, Aviant, Artem and Antonov, civil aviation complex №140.

In order to do so, current research need support of project coordinator and industrial partner

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